भारतीय मानक **IS 13810 : 2023**

Indian Standard

कोयले के फ्लोट और सिंक विश्लेषण के लिए रीति संहिता

(पहला पुनरीक्षण)

Code of Practice for Float and Sink Analysis of Coal

(First Revision)

ICS 73.040

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Solid Mineral Fuels and Solid Biofuels Sectional Committee, PCD 07

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Solid Mineral Fuels and Solid Biofuels Sectional Committee had been approved by Petroleum, Coal and Related Products Division Council.

The float and sink test is a routine exercise, especially in coal preparation plants to evaluate and cross-check the wash ability characteristics of coal. Float and sink tests are used universally which represent one of the basic coal cleaning characteristics required in expressing the results of coal cleaning tests. Most of the coal producing countries have adopted the procedure of float and sink analysis as a laboratory method of producing basic data for designing coal cleaning plant and subsequently for assessing its performance and efficiency. Due to different coal characteristics, there are likely to be differences in procedure in collecting samples of coal, in preparing them for float and sink analysis and in the laboratory procedure of making the analysis itself for different countries. These variations in techniques are more pronounced if the practices used in different countries are compared. Figures which are obtained may be misleading on account of significant variations by different operators in different countries.

In order to obviate these inherent variations and yet to preserve flexibility and choice by those concerned with all the uses of float and sink analysis, it is necessary to select and define those parts of the operations which call for wide range agreement though not necessarily for formal standardization.

Accordingly, this code has been prepared to specify the principles of float and sink analysis with particular reference to the sampling and preparation of samples and to the subsequent procedure of the float and sink analysis to the extent that any operator acting on these principles will obtain substantially the same results as any other operator adopting the same principles on any given run-of-mine coal or any product there from obtained by a cleaning or separation process. What is implicit in this code, is the need to give general rules for guidance which will ensure a satisfactory standard of work and of reliability of results, while still allowing sufficient flexibility as to the apparatus and reagents which may be used.

This standard was first published in 1993. This (*first*) revision has been taken up to keep pace with the latest technological developments and international practices. The following major changes have been made during this revision:

a) ‘Table 3 Material with relative density and size distribution to give a relatively stable suspension’ and ‘Table 5 Presentation of float and sink data and calculation for washability curves’ have been modified; and

b) Also, a new table ‘Table 6 Presentation of Float and Sink Data for high ash non-coking coal’ has been incorporated.

'Method of sampling of coal for float and sink analysis', namely IS 6345 : 1996 has been separately prepared in this field and in the preparation of the present code, assistance has been drawn from the following International Standards by International Organization for Standardization (ISO):

ISO 7936 : 1992 Hard coal — Determination and presentation of float and sink characteristics — General directions for apparatus and procedures

The composition of the committee, responsible for the formulation of this standard is listed in Annex D.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical numerical values (*second revision*)’.

Indian Standard

CODE OF PRACTICE FOR FLOAT AND SINK ANALYSIS OF COAL

(*First Revision*)

1 SCOPE

1.1 This Indian Standard describes general direction for the apparatus and procedures, using relative density separation methods for determining the float and sink characteristics of raw coal and of products from coal preparation plants. The coal washability data prepared on the basis of the procedure are of use in designing and redesigning plant and in predicting, controlling and assessing the performance of the plant.

1.2 It is essential that when tests other than these for routine control purposes are carried out, there is precise instruction regarding size ranges and relative density fractions to establish the scope of information and accuracy required.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text constitute the provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most editions of the standards listed below:

IS No.	*Title*
IS 437 : 2020	Size analysis of coal and coke for marketing (*fourth revision)*
IS 6345 : 1996	Method of sampling of coal for float and sink analysis (*first revision*)

3 SAMPLING

3.1 Mass of Bulk Sample

3.1.1 The quantity of sample and consequently the degree of accuracy obtained in a float and sink test may be varied according to the purpose for which the tests are being carried out, the three main categories being:

a) Investigation of characteristics of raw/crushed coal;
b) Comprehensive plant efficiency tests; and
c) Plant control tests.

The mass of the bulk sample should be sufficient to contain the minimum quantities in each fraction as given in Table 1 which is for guidance of category 1 and 2 type of tests or for use with an unknown sample and may not be practicable in the case of routine tests with plant products or bore core coal samples.

3.1.2 The number of discrete particles to be aimed for any size fraction should not be less than 2 000. The masses given in Table 1 will generally ensure that the number of particles is adequate for raw coal.

3.1.3 Since some coal give low yields in the intermediate relative density fractions there may be insufficient material for analytical requirements and the recommended mass of the sample may have to be substantially increased to meet the requirements of not less than 20 g and not less than 10 particles in each relative density fraction.

3.1.4 In taking a bulk sample it is better to collect more sample than to be placed in the situation of not having sufficient material. In order to carry out testing on the larger sizes in Table 1, the sample may have to be of the order of 5 tonne or greater.

3.1.4.1 In a newly opened mines, a trial shaft or other appropriate location the mass of bulk sample taken should not be less than 10 tonne.

3.1.5 For bore cores the masses recommended in Table 1 may only infrequently be obtained. For this reason, core plies or sections should be selected as larger as possible and subdivision of the crushed ply or section prior to float and sink testing should be avoided.

3.2 Method of Sampling

Sampling shall be carried out in accordance with IS 6345

3.2.1 *Raw Coal*

The recommended masses of raw coal for a given size fraction to ensure adequate numbers of particles for separation are shown in Table 1.

3.2.2 *Plant Products*

For clean coal, middling, rejects/sink samples the minimum quantity may be increased than that of raw coal if so, warranted in specific cases of separation, to ensure that adequate amounts of misplaced materials are available in any relative density fraction, so that desired degree of accuracy is obtained from the tests.

Samples should be taken as soon as practicable after the material leaves the cleaning unit in order to minimize the breakage.

When a screen analysis of a plant product is made in connection with a cleaning plant efficiency test, it will be found that there is some material below the nominal bottom size being treated in the cleaning unit. The mass and particle size range of this undersize material should be recorded.

Table 1 Minimum Mass for a given Size Fraction

(*Clauses* 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.2.1, 3.2.2, 3.2.3, C-2, C-6, C-8 *and* C-9)

Sl No. (1)	**Size Fraction** (*see* Note) **Square Hole** (2)	**Typical Recommended Minimum Masses for Raw Coal, kg** (3)
i)	200 to 100/75 or any size fraction having top size of particles of 200 mm	1 500
ii)	100/75 to 50 or any size having top size of particles of 100 mm	1 000
iii)	50 to 25 or any size having top size particles of 50 mm	500
iv)	25 to 13 or any size having top size of particles of 25 mm	250
v)	13 to 6 or any size having top size of particles of 13 mm	50
vi)	6 to 3 or any size having top size of particles of 6 mm	15
vii)	3 to 1.5 or any size having top size of particles of 3 mm	5
viii)	1.5 to 0.5 or any size having top size of particles of 1.5 mm	2
ix)	Below 0.5 mm	1

NOTE — The sizes shown in the above table may be supplemented or replaced by other sizes. Quantities within size ranges specified will be determined by the number of separations to be made and the quantitative distribution of the components in terms of relative density.

Same applies to the particles that would be larger than the nominal top size of the cleaning products.

In sampling pulp, the mass of the (dried) solids shall comply with the requirements of Table 1. Increments shall be taken at regular time intervals, preferably on half-an-hour basis over the total cross section of the pulp stream either manually or by mechanical means, using a sampling device having a capacity at least equal to or twice that of the recommended minimum increment. Care shall be exercised in order to ensure that none of the sample is lost by splashing.

A comprehensive cleaning plant efficiency test involves a systematic mass balance of all materials entering and leaving the plant. In this case the mass and moisture content of the raw feed, the mass and moisture content '*as received*' of all cleaned products, discard, reject etc and the volume and solids content in the effluent will be required. The mass of all materials is calculated to a uniform air-dried moisture basis and the feed entering and products leaving the plant are balanced against each other. The efficiency of the cleaning plant is assessed from the actual and washability yields and grades. The analysis of the raw coal feed built by the commutation from the masses and analysis of all products is more reliable than that obtained by direct examination, and it is therefore, used for the calculation of the theoretical yields (not clear).

3.2.3 *Plant Control Testing*

Routine samples are taken regularly for the purpose of determining the average efficiency of a cleaning plant. They may represent daily, weekly or even longer periods of running. The mass taken may be less than that prescribed in Table 1 depending on the reason for the test, but if any dispute arises over the accuracy of the results, then sample masses in accordance with **3.2.1** and **3.2.2** shall be used.

Both the size distribution and the ash percentage of the raw coal coming from a working face or different seams of a single mine may vary during a shift as well as from day to day. It is essential that the duration of sampling should be of a long enough period to take care of such variations.

4 PREPARATION OF TEST SAMPLE

4.1 Size Analysis

The sample shall be spread out on an impervious base, preferably under shelter, and allowed to dry sufficiently for screening purposes. It should then be screened using a suitable range of apertures preferably following √2 (= 1.4142….) series. Suppose the coarsest aperture size to be used is 75 mm, then the next sizes in decreasing order would be (75/√2 =) 53 mm, (53/√2 =) 37.5 mm etc.

The quantity of material passing the 25 mm screen is usually more than the amount required and may be divided before proceeding to the next size screen. Further division may be necessary at lower sizes.

NOTES

1 The above screening process may be preceded by a sample treatment operation designed to simulate particle break-down which may occur in a coal preparation plant. Where it is not possible to size efficiently due to fine particles adhering to larger particles, then wet screening shall be used to ensure that the fine particles report to the proper size fraction. In case of size analysis of fines below 0.5 mm wet screening has to be done using finer sieves.

2 Pulp and discard samples should be screened promptly to avoid excessive shale break-down.

4.2 Pilot Testing

Pilot testing frequently carried out on a representative sample in order to determine the pattern of behaviour which the bulk material will follow. This knowledge enables the operator to plan the actual test in such a way that unnecessary operations are avoided so that the test is carried out more expeditiously and with less effort. The pilot test or previous knowledge may indicate an advantage in commencing the separation at either the highest or lowest relative density.

A sample which will give a high yield at either of these points should be separated at that point so that the bulk of the sample can be removed in one operation.

In cases where there is only a small yield at one or two consecutive relative density fractions, it is better if these fractions are combined before carrying a full treatment process. Similar merger of successive stages can be made while doing the screening of samples. Within these limits it is possible to vary the procedure without affecting the outcome of the test, and in many cases improving its accuracy and reducing the time and labour involved.

5 FLOAT AND SINK TESTING

5.1 Float and Sink Medium

5.1.1 *Basis of Selection*

The medium which is to be used for the separation may be a mixture of organic liquids, aqueous solutions of inorganic salts or solid in aqueous suspensions. The choice of medium is also governed to some extent by the bulk and particle size of the coal being tested, its rank, relative density and the purpose for which the separation is being carried out. The most suitable range of relative densities will have to be determined by trial and error, but would normally include 1.3, 1.4, 1.5, l.6, 1.7, 1.8, 1.9 and 2.0. Relative densities less than 1.3 and above 2.0 may be required depending upon the raw coal characteristics. Additional separation at intermediate relative densities will be found useful where cumulative ash is increasing rapidly in relation to the cumulative yield (*see* **3.1.3** reference the stipulation with regard to the minimum of 20 g and 10 particles).

If it is known or suspected that the sample will disintegrate or otherwise react on contact with water or aqueous solutions, separations must be carried out using organic liquids. However, the fact that the raw coal will react with water will affect its behaviour in the cleaning process and any information which will give guidance should be obtained for reference purpose.

5.1.2 *Organic Liquids*

Where the separation is critical, particularly at finer sizes, the use of organic liquids is preferred (*see* Notes) because of their low viscosity, volatility and inertness towards shales. Some organic liquids, with their relative densities are listed in Table 2.

NOTES

1 When the relative densities of less than 1.6 are required mixtures of tetrachloroethylene and benzol may be used but for higher relative densities of 1.6 to 2.5, mixtures of tetrachloroethylene and bromoform may be used. Organic liquids are costly but are frequently preferred to aqueous solutions since the products of the separation are easier to deal with prolonged washing and drying times are unnecessary because of the volatility of the solvents. They should be used carefully, and it is recommended that solvent recovery be practiced, particularly by drainage, after the coal is removed from the separation tank.

2 Adequate ventilation is essential, preferably down draught (*see* Fig. 3) as many solvent vapors are toxic and present a serious health hazard. Suitable protection to avoid contact with the skin is also required. Many countries have statutory requirements concerning the use of organic liquids with respect to toxicity and fire.

5.1.3 The following equation may be used as a guide for determining the volumes of liquids required in formulating a mixture at the desired relative density. It is important that the relative density of the resultant mixture be checked, for example, by means of a hydrometer with minimum scale divisions of 0.002.

$$V_m = V_t \text{ x } \frac{(p_t - p_p)}{(p_m - p_p)}$$

where

V_m = volume of the liquid with higher relative density;
V_t = volume of mixture desired;
p_m = higher liquid relative density;
pt = desired relative density of the mixture; and
p_p = lower liquid relative density.

5.1.4 *Inorganic Solutions*

This procedure shall not be used if any portion of the sample is subjected to disintegration in water to an extent which will influence the accuracy of the test. Inorganic solutions may be used for the samples upto a size of 13 mm and maximum upto a relative density of 1.7.

Zinc chloride is a commonly used inorganic salt, but it has several disadvantages which should be considered carefully. Zinc chloride solutions are more viscous than organic liquids, therefore particles need more time to report to float or sink. Zinc chloride solutions are corrosive; hence care should be exercised in the choice of the container used in the test. Skin contact should be strictly avoided. Furthermore, the pores of the sample frequently become permeated by the zinc chloride solution which is difficult to remove even with prolonged washing with fresh water. The presence of residual zinc chloride may introduce mass errors and may also affect the analysis of the ash. Washing with hot water might be helpful to bring down the zinc chloride content of the samples to satisfactory level. However, presence of residual zinc chloride content may be estimated by means of colorimetric tests with the wash water, whenever so warranted and examined whether it may affect the analysis results. Efforts should always be made to use zinc chloride powder to prepare the solution. That makes easy dissolution and stable solution. It is advisable not to use lumpy or coarse-grained zinc chloride.

5.1.5 *Solids its Aqueous Suspension*

For the preparation of stable aqueous heavy medium suspension using insoluble material, refer Table 3**,** col (4) — nominal top size micron.

5.1.5.1 The procedure for using aqueous suspension is similar to that recommended for use with inorganic solutions. The separated fractions are thoroughly washed with water to remove adhering medium. It is important to have a device for accurately determining the relative density of the suspension. A suitable apparatus is shown in Fig. 1.

5.1.5.2 Two important advantages of suspension are that they are non-toxic and non-volatile and therefore fume extraction is not required. Provided products are washed free of medium, no adverse effects on product quality occur. They are not recommended for testing particles below 6 mm.

5.2 Apparatus

The apparatus to be used should be simple as possible commensurate with what has to be achieved, the principle criteria being that it should be unaffected by the solutions involved and convenient for use. Types of apparatus which have been found suitable are shown in Fig. 2 to 5.

Table 2 Physical Properties of Organic Liquids Used in Float and Sink Analysis
(*Clause* 5.1.2)

Sl No. (1)	Organic Liquids (2)	Relative Density (3)	Distillation on Range or Boiling Point (°C), at 100 kN/m (100 kPa) (4)	Viscosity at 20 °C, mN s/m (mPa/s) (5)	Vapour Pressure at 20 °C, kN/m (kPa) (6)	Flammable (7)
i)	White spirit	0.77	30-200	—	—	Yes
ii)	Petroleum spirit (*see* Notes 3 and 4)	0.73	37-185	0.548	25.33	Yes
iii)	Benzol	0.87	80.5	0.55	__	Yes
iv)	Kerosene	0.75	165-230	1.365	0.11	Yes
v)	*o*-Xylene	0.88	144.4	0.810	0.68	Yes
vi)	*m*-Xylene	0.86	139.0	0.620	0.85	Yes
vii)	*p*-Xylene	0.86	138.4	0.648	0.92	Yes

Table 2 (*Concluded*)

Sl No. (1)	Organic Liquids (2)	Relative Density (3)	Distillation on Range or Boiling Point (°C), at 100 kN/m (100 kPa) (4)	Viscosity at 20 °C, mN s/m (mPa/s) (5)	Vapour Pressure at 20 °C, kN/m (kPa) (6)	Flammable (7)
viii)	Bromoform (tribromomethane)	2.79	150.0	2.152 (15 °C)	0.6	No
ix)	Sym- tetrabromoethane (Acetylene tetrabromide)	2.96	239.0	12.0	0.01	No
x)	Tetrachloroethylene (perchloroethylene)	1.61	120.8	1.0	1.83	No
xi)	Sulphuric acid	1.84	—	—	—	No

NOTES

1 Particular attention is drawn to the fact that many solvent vapours present a serious health hazards and hence adequate ventilation, preferably down draught is essential.

2 As the use of some organic liquids is governed by safety regulations, the user is urged to ensure compliance with the relevant statutory regulations.

3 If petroleum spirit is used, it should be lead free.

4 Mixtures of air and petroleum spirit vapour are highly explosive.

5 Carbon Tetrachloride is banned presently and it should not be used.

Table 3 Material with Relative Density and Size Distribution to Give a Relatively Stable Suspension

(*Clause* 5.1.5 *and* B-10)

Sl No. (1)	Materials (2)	Relative Density (3)	Nominal Top Size, Micron (4)	Remarks (5)
i)	Magnetite	5.0	38	As used in coal preparation plants.

NOTE — Float and sink test using suspensions is not being practiced in India presently. However, magnetite is used as a media for beneficiation of coal using heavy medium process.

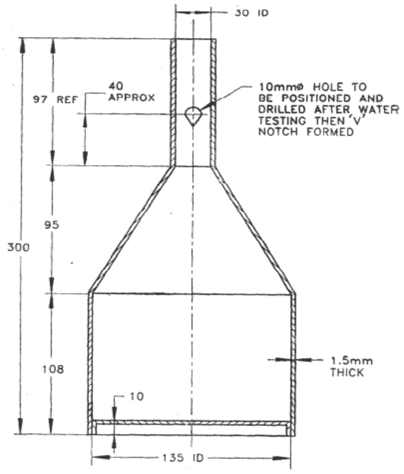
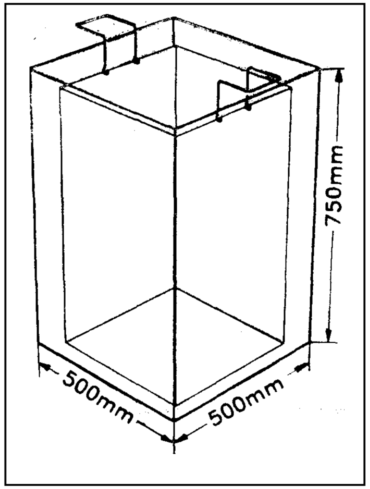
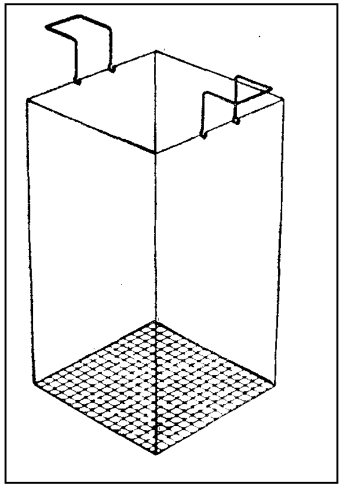

30 ID
97 REF
40 APPROX
10mmø HOLE TO BE POSITIONED AND DRILLED AFTER WATER TESTING THEN 'V' NOTCH FORMED
95
300
108
1.5mm THICK
10
135 ID

FIG. 1 SECTIONAL ELEVATION OF 2 LITRE MEASURING VESSEL FOR DETERMINATION OF DENSITY OF AQUEOUS SUSPENSION

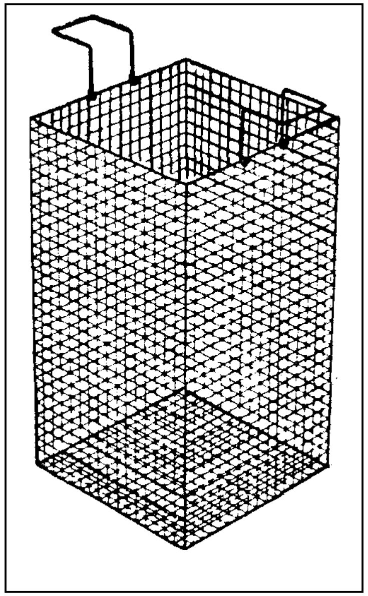
NOTE — Vessel constructed from brass. All joints to be brazed.



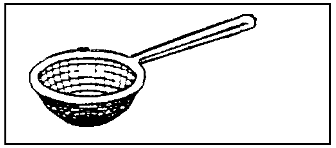
RECTANGULAR TANK WITH INNER LINER



RECTANGULAR INNER LINER WITH WIRE MESH BOTTOM ONLY

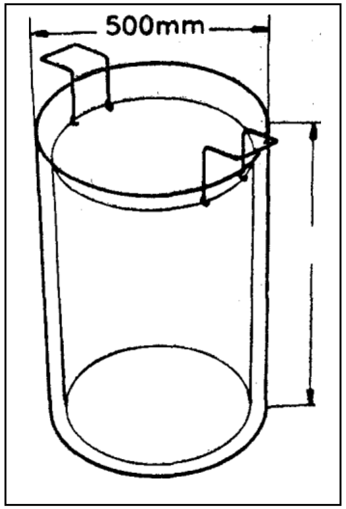


RECTANGULAR INNER LINER WITH WIRE MESH SIDE AND BOTTOM

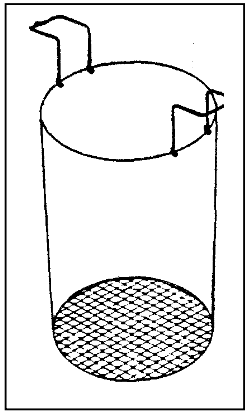


WIRE MESH STRAINER

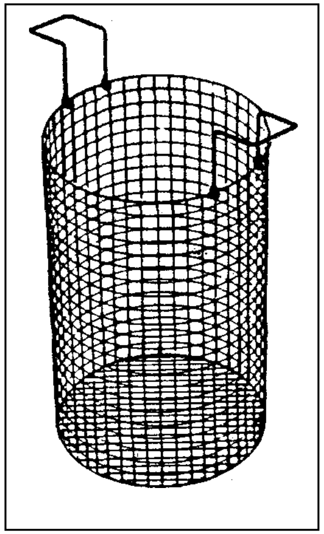
2A Rectangular Float and Sink Apparatus



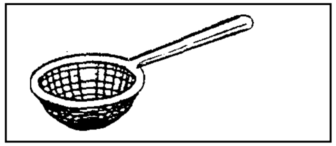
CYLINDRICAL TANK WITH INNER LINER



CYLINDRICAL INNER LINER WITH WIRE MESH BOTTOM ONLY



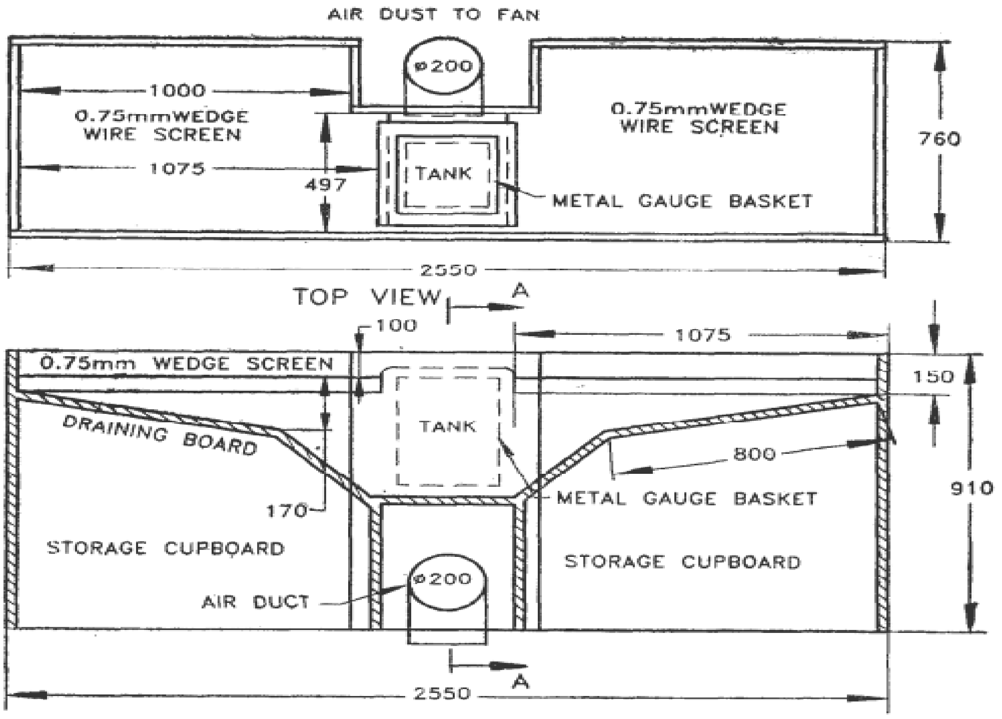
CYLINDRICAL INNER LINER WITH WIRE MESH



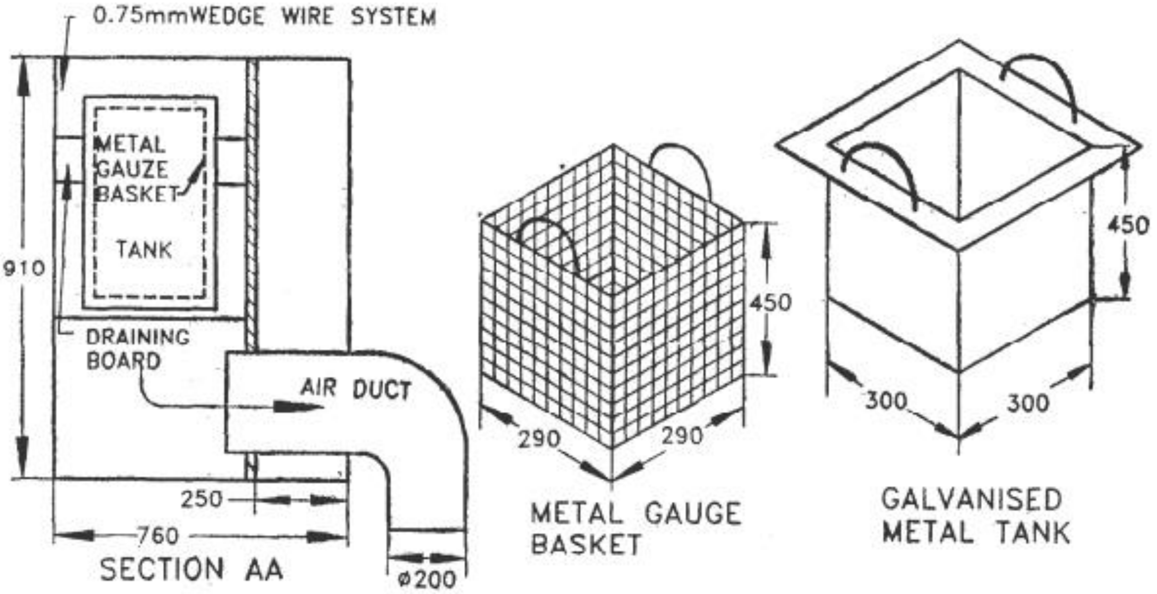
WIRE MESH STRAINER

2B Cylindrical Float and Sink Apparatus

FIG. 2 FLOAT AND SINK APPARATUS FOR SEPARATION OR COARSE COAL



INTERNAL FRONT VIEW



All dimensions in millimetres

FIG. 3 SUITABLE FLOAT AND SINK BENCH

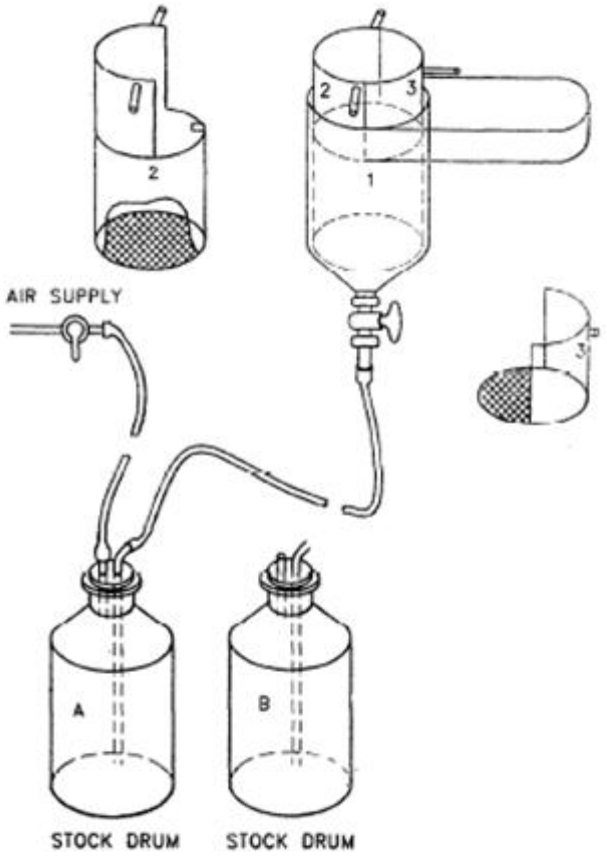


FIG. 4 SUITABLE FLOAT AND SINK APPARATUS FOR 4 mm TO 0.5 mm FRACTIONS

The apparatus for separating the float fraction from the sink fraction may consist of a basket with a movable partition which allows the float and sink fractions to be dealt with simultaneously while keeping them separate. Alternatively, a tank with a fine mesh base made to fit inside another tank forms a useful means of recovering floats and sinks separately. In this instance, the floats are skimmed off the liquid surface using a fine mesh scoop and the sinks are recovered by raising the inner perforated base tank and draining off the liquid.

5.3 Methods

Practical hints for float and sink testing are given in Annex A.

5.3.1 *Basic Method*

The separation tank is partly filled with the required medium, the relative density of which is then checked using a suitable hydrometer. The relative density of the medium should be adjusted to the correct reading and be maintained at this figure by frequent checking to ensure that it remains within the range of ± 0.002 of the desired relative density for the duration of the test.

An increment of the size fraction under test, sufficient to form a thin layer, is introduced into the tank containing the medium and the same is gently agitated. Care must be taken not to overload the tank as this is liable to interfere with the separation of entrained near-density material. After allowing sufficient time for separation, the float material is removed and collected on a draining platform or tray. The settled sinks material is agitated to release any entrained float material. The time of separation will vary according to the type of separating medium used and the coal particle size. This process is repeated until the entire test sample has been separated. All float materials are washed free from medium if necessary, dried in air, weighed and when required prepared for analysis. The sink material needs to be well drained off the adhered liquid, care being taken to maintain the relative density of the succeeding liquid, by introducing only completely drained material from the previous test. It is then introduced into the medium of next higher relative density. The float material from this separation is also washed free from medium, if necessary, dried in air, weighed and when required prepared for analysis.

This procedure has to be repeated until all the size fractions have been tested at all relative densities.

NOTE — To reduce the time required for gravimetric separation of coals finer than 1 mm a centrifugal float and sink procedure may be employed, as described in Annex B.

5.3.1.1 *Testing in ascending sequence*

This sequence is used where it is known from pilot testing or previous knowledge that the majority of the sample is of low relative density. In this way a large proportion of the sample is removed from the test at the first separation, thereby reducing breakage and handling.

5.3.1.2 *Testing in descending sequence*

This sequence is used where it is known from pilot testing or previous knowledge that the majority of the sample is of high relative density. The procedure for testing is similar to that described in **5.3.1.1** except that the test sample is introduced firstly into the medium of highest relative density. The sinks fraction is washed free from adhering medium if necessary, dried in air, weighed, and when required prepared for analysis. The float fraction is thoroughly drained and introduced into the medium of the next lower relative density. The completely drained material does not alter the relative density of the next liquid. The sink material is washed free from medium if necessary, dried in air, weighed and when required prepared for analysis. This process is repeated until separation in the medium of lowest relative density is carried out. As most of Indian coals contain majority of materials in density range 1.40 and 1.60, it may be beneficial to start the testing at a bath density of 160 and continue in descending sequence. After completion of these tests, the sinks from the bath density of 1.60 may be removed, drained off the adhered liquid and tested in higher density bath and the tests in ascending sequence.

As the testing in ascending, a large proportion of the sample is removed from the test at the first separation thereby reducing breakage and handling to minimize the generation of fines.

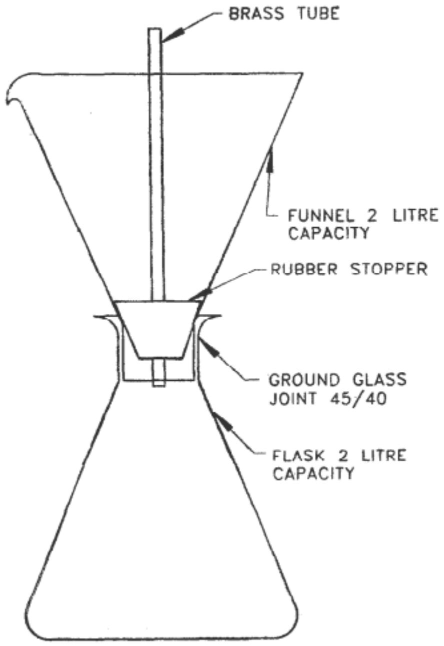


FIG. 5 SUITABLE APPARATUS FOR SEPERATION OF LESS THAN 0.5 mm COAL

5.3.1.3 *Testing procedure for samples containing small proportions of intermediate relative density material*

Where it is known from pilot testing or previous knowledge that the majority of the test sample is a mixture of both low and high relative density with little intermediate relative density material, the sample is introduced firstly in the medium of low relative density. The float fraction is drained, washed where necessary, air dried, weighed and when required prepared for analysis.

The sink fraction is drained and transferred to the medium of highest relative density. The sink fraction from this separation is drained, washed where necessary, air dried, weighed and when required prepared for analysis. The float fraction, now of relatively small may be introduced into a medium in either order of relative density and treated as in **5.3.1.1** or **5.3.1.2.**

This method eliminates moving large masses of material through the intermediate relative densities.

5.3.1.4 *Testing procedure for samples containing a large proportion of intermediates relative density material*

Where it is known from pilot testing or previous knowledge that the sample contains a large proportion of intermediate relative density material, the sample is introduced into a medium of intermediate relative density which will give an approximate even split in the mass to be further treated. The procedure with the float and sink fractions would be as in **5.3.1.1** and **5.3.1.2.**

5.3.2 *Schematic Method*

A typical procedure is prescribed in Annex G and an example is shown diagrammatically in Fig. 6.

6 REPORT

6.1 Size Analysis

The results of a size analysis may be represented as shown in Table 4. If graphical representation is necessary, it should be prepared in accordance with IS 437.

6.2 Float and Sink Data

6.2.1 The results of float and sink testing of each size fraction may be recorded as shown in Table 5.

The data given is for a coking coals sample and the specific gravity ranges from 1.3 to 2.0 with an interval of 0.1 specific gravity. If it is observed that the fraction greater than 2.0 specific gravity constitutes more than 25 percent then additional gravity that is 2.1 and 2.2 may be incorporated in the float and sink test. This may be done for W-VI grade raw coals presently being mined in Jharia and Bokaro coalfields.

Initially the results are recorded on the basis of 100 percent recovery for each size fraction, and then calculated to produce the cumulative float and sink data for that size fraction. These may be represented graphically in the form of washability curves (*see* Fig. 7) or a Mayer Curve (*see* Fig. 8).

Similarly, the float and sink data of high ash non-coking coal is shown in Table 6 and for the complete calculation the method as shown in Table 5 may be followed and similar washability and Mayer's curve as shown in Fig. 7 and Fig. 8 may be followed for interpretation.

6.2.2 Similar Tables may be prepared and presented graphically for combinations of size fractions, for the size analysis on proportional basis.

6.2.3 In order to produce full washability curves, it will be necessary to determine the ash percentage of each relative density fraction in each size range.

6.2.4 *Definitions*

6.2.4.1 *Washability*

Amenability of a coal for improvement in quality by cleaning.

6.2.4.2 *Washability curves*

It is the graphical representation of the washability test results; wherein relative density (specific gravity), and yield is kept in one co-ordinate, whereas ash percentage in the other co-ordinate.

There are two types of curves:

a) Standard curves; and
b) Non-standard curves.

6.2.4.2.1 *Standard curves*

There are four types of standard curves:

a) Washability characteristic curve

The curve is constructed by plotting the cumulative yield up to middle of a fraction (CMF) against the ash percentage of that fraction. If the coal particles are arranged vertically downwards according to increasing relative density, the particles located at the bottom of CMF will have an approximate ash percentage of the concerned fraction. Therefore, the washability characteristic curve indicates the variation of ash percentage from particle to particle in the increasing or decreasing order of relative density.

The shape and bends of the characteristic curve are of importance and the actual location or position of the curve on the graph paper has significance. When the characteristic has a marked upward concavity occurring below the half-way mark of yield the indication is that the coal is washable and will give a fairly large fraction of cleaned coal. If such concavity is missing, or is but feebly developed, the coal is more difficult to wash, and the more nearly the characteristic curve approaches a vertical line, then even more difficult it is to wash the coal.

b) Cumulative floats-ash curve

The curve is constructed by plotting the cumulative yield of floats at a relative density against the average ash percentage of this total floats. A point in the curve directly indicates the yield and ash percentage of the float that is obtained by washing the coal at a particular relative density.

c) Cumulative sinks-ash curve

The curve is constructed by plotting the cumulative yield of sinks at a relative density against the average ash percentage of this total sinks, a point in the curve directly indicates the yield and ash percentage of the sink that is obtained by washing/pre-washing the coal at a particular relative density.

d) Relative density yield curve

The curve is constructed by plotting the cumulative yield of floats or sinks at a relative density against the successive relative densities, a point in the curve directly indicates the yield of floats or sinks that is obtained by, washing the coal at a particular relative density.

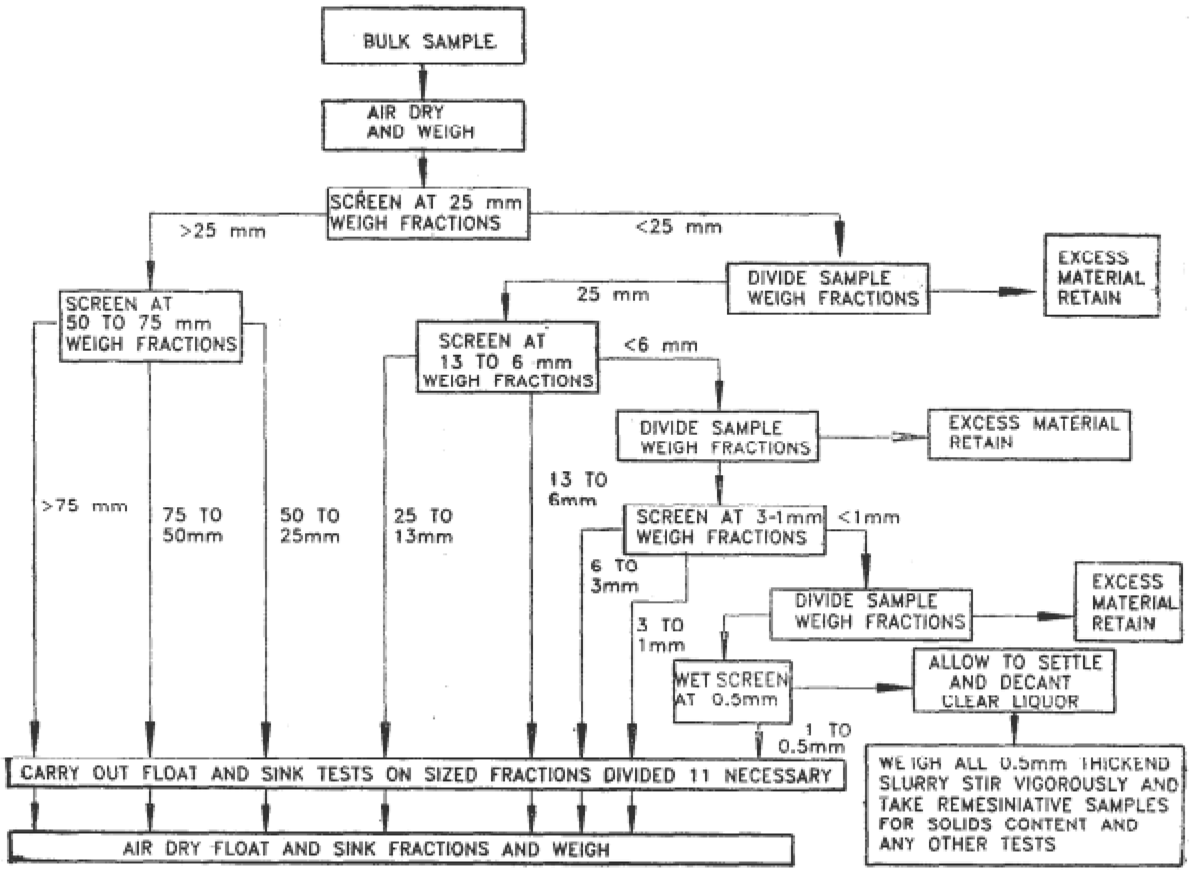

BULK SAMPLE
AIR DRY AND WEIGH
SCREEN AT 25 mm WEIGH FRACTIONS
>25 mm
<25 mm
DIVIDE SAMPLE WEIGH FRACTIONS
EXCESS MATERIAL RETAIN
SCREEN AT 50 TO 75 mm WEIGH FRACTIONS
25 mm
SCREEN AT 13 TO 6 mm WEIGH FRACTIONS
<6 mm
DIVIDE SAMPLE WEIGH FRACTIONS
EXCESS MATERIAL RETAIN
13 TO 6mm
>75 mm
75 TO 50mm
50 TO 25mm
25 TO 13mm
SCREEN AT 3-1mm WEIGH FRACTIONS
<1mm
6 TO 3mm
DIVIDE SAMPLE WEIGH FRACTIONS
EXCESS MATERIAL RETAIN
3 TO 1mm
WET SCREEN AT 0.5mm
ALLOW TO SETTLE AND DECANT CLEAR LIQUOR
1 TO 0.5mm
CARRY OUT FLOAT AND SINK TESTS ON SIZED FRACTIONS DIVIDED 11 NECESSARY
WEIGH ALL 0.5mm THICKEND SLURRY STIR VIGOROUSLY AND TAKE REMESINIATIVE SAMPLES FOR SOLIDS CONTENT AND ANY OTHER TESTS
AIR DRY FLOAT AND SINK FRACTIONS AND WEIGH

FIG. 6 A SUGGESTED SCHEMATIC TREATMENT OF A RUN OF MINE SAMPLE

Table 4 Size Analysis
(*Claus*e 6.1)

Sl No. (1)	**Size fraction (Square Hole)** (2)	**Mass Percentage** (3)	**Material Rational Percent** (4)	**Material Passing Percent** (5)
i)	Plus 100	Nil	Nil	100.0
ii)	100-75	15.8	15.8	84.2
iii)	75-50	18.0	33.8	66.2
iv)	50-25	24.0	57.8	42.2
v)	25-13	17.8	75.6	24.4
vi)	13-6	10.0	85.6	14.4
vii)	6-3	4.3	89.9	10.1
viii)	3-1	4.0	93.9	6.1

Table 4 (*Concluded*)

Sl No. (1)	Size fraction (Square Hole) (2)	Mass Percentage (3)	Material Rational Percent (4)	Material Passing Percent (5)
ix)	1-0.5	2.4	96.3	3.7
x)	-0.5	3.7	100.0	Nil
		Total : 100.0		

Table 5 Presentation of Float and Sink Data and Calculation for Washability Curves

(*Clause* 6.2 *and Fig*. 7)

Details of sample :

- i) ROM crushed to below 13 mm
- ii) Size fraction : 13-0.5 mm
- iii) Proportion of total feed : 95.8 percent

			On Size Fraction Basis											
	Relative Density Fractions						**Cumulative Floats**			**Cumulative Sinks**				
Sl No.	Sink	Float	Mass Percent	Ash Percent	Mass of Ash (3)x(4)	Relative Density	Mass Percent Σ (3)↓	Mass of Ash Σ (5)↓	Ash Percent (8/7)	Mass Percent Σ (3)↑	Mass of Ash Σ (5)↑	Ash Percent (11/10)	Cumulative from Top to Middle Mass percent [(7) - (8)]/2	Mayers Point [(7)x(9)]/100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	—	—	—	—	—	—	—	—	—	100.0	2875.45	28.8	—	—
ii)	—	1.30	1.8	1.4	2.52	1.30	1.8	2.52	1.4	98.2	2872.93	29.3	0.9	0.025
iii)	1.30	1.40	7.5	9.9	74.25	1.40	9.3	76.77	8.3	90.7	2798.68	30.9	5.6	0.8
iv)	1.40	1.45	11.2	18.6	208.32	1.45	20.5	285.09	13.9	79.5	2590.36	32.6	14.9	2.9
v)	1.45	1.50	22.5	24.4	549.00	1.50	43.0	834.09	19.4	57.0	2041.36	35.8	31.8	8.3

Table 4 (*Concluded*)

	Relative Density Fractions		**On Size Fraction Basis**											
							Cumulative Floats			**Cumulative Sinks**				
Sl No.	Sink	Float	Mass Percent	Ash Percent	Mass of Ash (3)x(4)	Relative Density	Mass Percent Σ (3)↓	Mass of Ash Σ (5)↓	Ash Percent (8/7)	Mass Percent Σ (3)↑	Mass of Ash Σ (5)↑	Ash Percent (11/10)	Cumulative from Top to Middle Mass percent [(7) - (8)]/2	Mayers Point [(7)x(9)]/100
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
vi)	1.50	1.55	21.0	28.2	592.20	1.55	64.0	1426.29	22.3	36.0	1449.16	40.3	53.5	14.3
vii)	1.55	1.60	15.5	33.1	513.05	1.60	79.5	1939.34	24.4	20.5	936.11	45.7	71.8	19.4
viii)	1.60	1.70	12.2	39.3	479.46	1.70	91.7	2418.80	26.4	8.3	456.65	55.0	85.6	24.2
ix)	1.70	1.80	3.5	47.5	166.25	1.80	95.2	2585.05	27.2	4.8	290.40	60.5	93.5	25.9
x)	1.80	2.00	4.0	57.5	230.00	2.00	99.2	2815.05	28.4	0.8	60.40	75.5	97.2	28.2
xi)	2.00	—	0.8	75.5	60.40	—	100.0	2875.45	28.8	—	—	—	—	28.8
xii)	Total	—	100.0	28.75	2875.45	—	—	—	—	—	—	—	—	—

Table 6 Presentation of Float and Sink Data for High Ash Non-Coking Coal
(*Clause* 6.2.1)

Sl No.	Relative Density Fractions		Mass Percent	Ash Percent
	Sink	Float		
(1)	(2)	(3)	(4)	(5)
i)	—	1.4	16.9	14.8
ii)	1.4	1.5	17.1	26.8
iii)	1.5	1.6	7.5	37.2
iv)	1.6	1.7	5.3	44.8
v)	1.7	1.8	3.7	52.7
vi)	1.8	1.9	2.3	58.2
vii)	1.9	2.0	9.8	71.3
viii)	2.1	2.2	16.9	79.2
ix)	2.2	—	20.5	87.0
x)	—	—	100.0	53.7

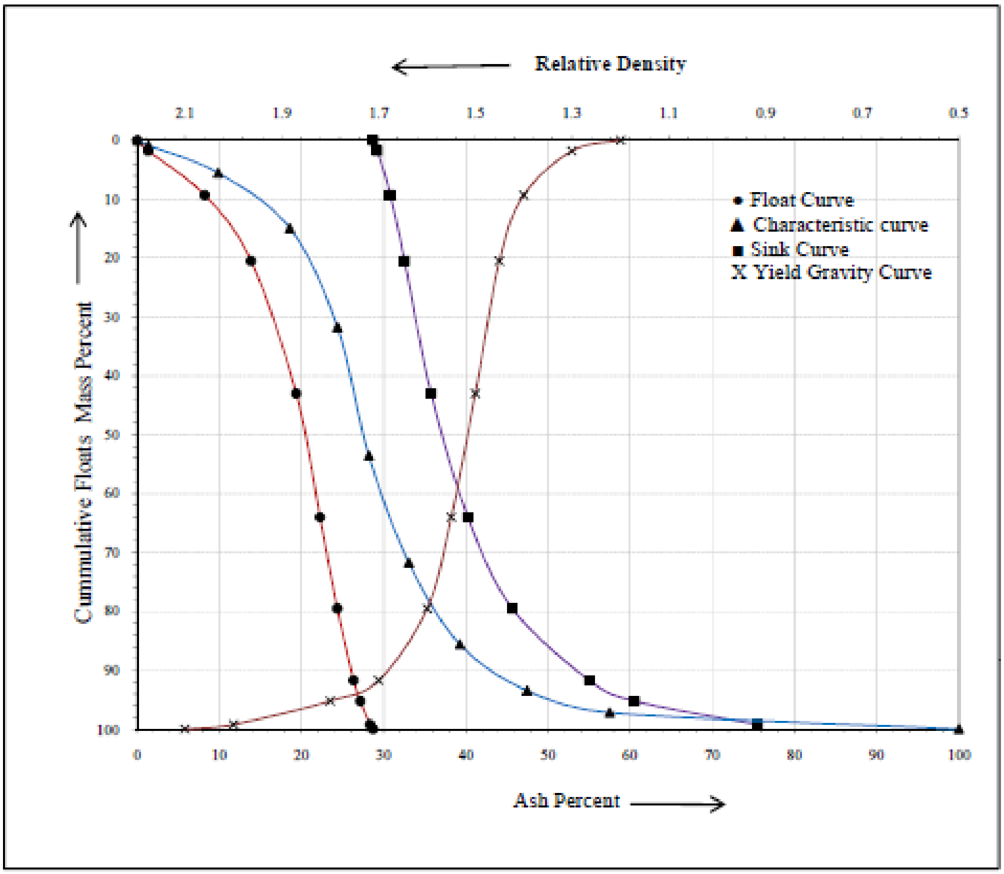
6.2.4.2.2 *On-standard curves*

a) Near gravity material (NGM) curve

The curve is sometimes constructed to measure the ease and/or difficulty of washing namely "the ± 0 10 relative density (specific gravity)” also known as "the near gravity material curve". The curve is constructed with any desired specific gravity of separation against numerical difference of yield of ± 0.10 of the desired specific gravity.

b) Mayer curve (M-curve)

The curve is constructed from float and sink analysis by plotting cumulative weight of ash (ash unit or ash quantities) against cumulative weight percentages of floats on a vectorial diagram in which the projection of the vector on the ordinate represents the percentage weight content, of coal and direction of the vector represents the percent content of ash. (*see* Fig. 8)



ROM crushed to below	13 mm
Size fraction	13-0.5 mm
Proportion of total	95.8 mm

Legend (*columns refer to* Table 5*)*

Curve 2 Cumulative floats curve (column 7 plotted against column 9)
Curve 2 Characteristic ash curve (column 13 plotted against column 4)
Curve 3 Cumulative sinks curve (column 10 plotted against column 12)
Curve 4 Yield gravity curve (column 6 plotted against column 7)

FIG. **7** WASHABILITY CURVE

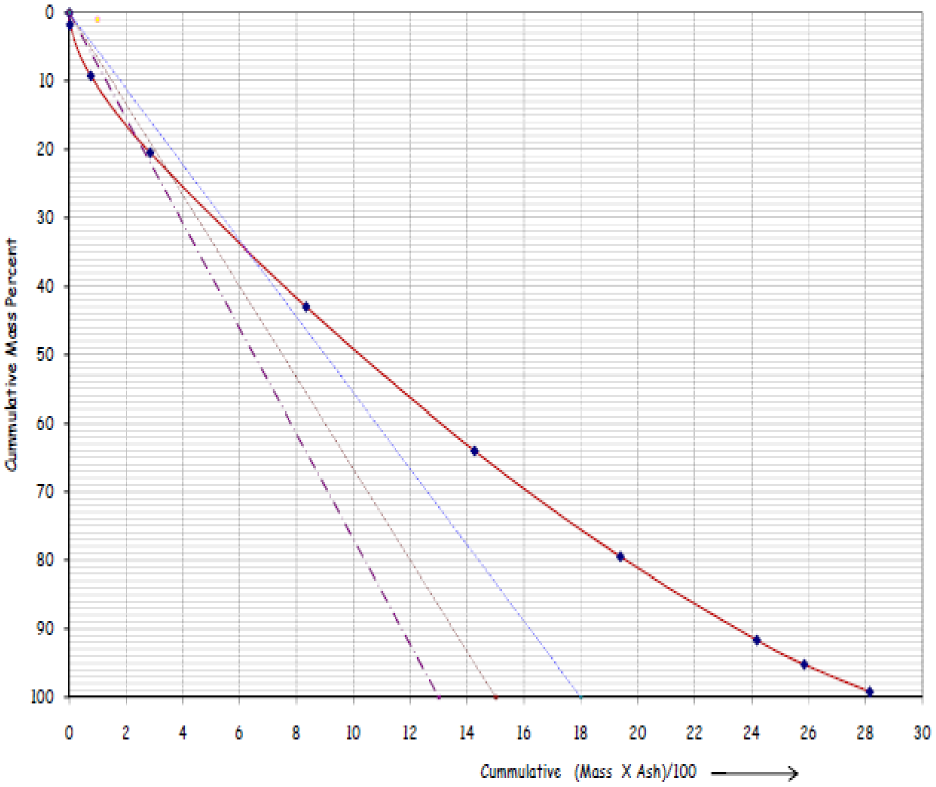


FIG. 8 MAYER'S CURVE

ANNEX A

(*Clause* 5.3)

PRACTICAL HINTS IN FLOAT AND SINK TESTING

A-l Wedge wire drainage panels on float and sink benches (*see* Fig. 3) should be hinged or loose to facilitate cleaning.

A-2 Fit baskets and containers with lifting handles (*see* Fig. 2 and 3).

A-3 Where material is adhering to large pieces, agitate in water using the basket and container shown in Fig. 2.

A-4 A graduated 2 l flask may be used for measuring the relative density of suspensions.

A-5 Where a large mass is to be divided it may be convenient to use the shovel by the shovel method.

A-6 In wet screening it may be advantageous to dry screen first then wash the oversize fraction in a container with water, reallocating the pulp.

A-7 When a down draught bench is not available it is essential to conduct tests using organic liquids out of doors, or alternatively in an open sided building.

A-8 Air drying is often more rapid in an open-sided building.

A-9 Petroleum spirit is a much more convenient diluent than white spirit.

A-10 Some inorganic salts react exothermically when dissolved in water. Relative density tests should be carried out only when the solution has cooled to normal temperature.

A-11 As it is advisable to restrict the float particles to a thin layer, a wide mouthed vessel saves time in the test.

A-12 For accelerated drying, samples which have been separated by heavy organic liquids should be washed with a more rapidly evaporating non-toxic compatible organic liquid.

ANNEX B

(*Clause* 5.3.1)

PROCEDURE FOR CENTRIFUGAL FLOAT AND SINK TEST

B-l A representative portion (80 g to 250 g) of the test size fraction is shared equally between the test tubes of the centrifuge.

B-2 The medium of the lowest relative density is poured into each test tube sufficient to exceed the volume of the solids but no more than two thirds fill the tube.

B-3 The contents of the test tube are mixed by stirring and the masses of the tubes adjusted to a common value by the addition of further medium where necessary to achieve balance.

B-4 Transfer the tubes to the centrifuge holders and rotate for 10 min at a rotation frequency of 2 000 revolutions per min.

B-5 Remove the floating solids from the tubes, carefully avoiding disturbing the sinks material. Filter the floats, air dry and weigh to an accuracy of ± 0.05 percent.

B-6 The medium along with the sinks may be transferred to a filter and after filtration it may be air-dried to remove the excess medium.

B-7 Return the sinks solid to the centrifuge tubes and repeat the procedure using the medium of next higher relative density.

B-8 When all the relative density levels have been completed, the final sinks material is removed, filtered, air-dried and weighed to an accuracy of ± 0.05 percent.

B-9 Each relative density fraction is prepared for analysis when required.

B-10 More than one representative portion of the test size fraction will need to be tested in order to satisfy the requirement of Table 3. Furthermore, if a relative density fraction is such that less than 20 g are recovered, it will be necessary to test further portions.

ANNEX C

(*Clause* 5.3.2)

SCHEMATIC PROCEDURE FOR FLOAT AND SINK TEST

C-1 In all cases the origin and mass of the samples shall be stated.

C-2 Obtain the sample in accordance with IS 6345 bearing in mind the minimum masses quoted in Table 1.

C-3 Spread the sample on a smooth clean base to air dry, if necessary, and weigh to an accuracy of ± 0.05 percent.

C-4 Screen at 25 mm (or whatever be the decided top size) weigh the oversize and undersize to an accuracy of ± 0.05 percent.

C-5 Screen the 25 mm oversize at the required screen sizes, weigh the fractions to an accuracy of ± 0.05 percent. Retain the size fraction for float and sink tests.

C-6 Reduce the mass of 25 mm undersize by sample division to the extent that the requirements of Table 1 can still be met. Weigh the products from the sample division to an accuracy of ± 0.05 percent and retain the excess product as a reserve.

C-7 Screen the divided 25 mm undersize at 13 mm and 6 mm. Weigh the size fraction 25 mm to 13 mm to an accuracy of ± 0.05 percent and retain for float and sink tests.

C-8 Weigh the undersize from the 6 mm screen and reduce the mass by sample division to the extent that the requirements of Table 1 can still be met. Weigh the products from the sample division to an accuracy of ± 0.05 percent and retain the excess product as a reserve.

C-9 Weigh the undersize from the 3 mm screen and reduce the mass by sample division to the extent that the requirements of Table 1 can still be met. Weigh the products from the sample division to an accuracy of ± 0.05 percent and retain the excess product as a reserve.

C-10 Screen (dry/wet) the divided 3 mm under size at 1.0 mm and 0.5 mm. Air dry the 3 to 1.0 and 1.0 mm to 0.5 mm size fractions (as and where applicable) and weigh to an accuracy of ± 0.05 percent. Retain the size fractions for float and sink test.

C-11 Allow the less than 0.5 mm solids to settle and remove the clear liquor. Weigh the thickened slurry. Agitate vigorously and take representative samples for the determination of solids content and any other tests that may be required.

C-12 Further sample division, if necessary, may be carried out on any of the size fractions prior to float and sink testing as long as required masses may be obtained in each of the density fractions.

C-13 Test each size fractions above 0.5 mm through the required range of relative densities (*see* **5**).

C-14 Air dry the density fractions until all traces of liquid are removed and weigh to an accuracy of ± 0.005 percent. Where heat is applied to assist evaporation, care should be taken such that any subsequent test work is not affected (*see* IS 6345).

NOTES

1 It is difficult to lay down a procedure that can be adopted in all cases, since Indian coals are heterogeneous in nature. This procedure therefore may be modified, where local experience with particular coals indicate that this would be an advantage, while bearing in mind the data that one is hoping to obtain.

2 Float and sink test is conducted for selection of the feed size of a proposed washery. In order to optimize the feed size yield testing is required at varying top sizes like -50 mm, -37 mm. -25 mm, 13 mm etc. These testing are required to be done from the same bulk sample or ROM, to facilitate comparative study; in each case 0.5 mm size fraction must be separately analysed.

3 Since hazardous organic liquids are used and washability test/float and sink test is carried out in the laboratory as well as in the plant, general safety appliances like gloves, goggles, aprons, boots, helmets and exhaust, table fan, etc, are required to be used. The personnel engaged in testing must be exposed to general first aid training.

ANNEX D

(*Foreword*)

COMMITTEE COMPOSITION

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